CIT Brains (Kid Size League)

Yasuo Hayashibara[1], Hideaki Minakata[1], Kiyoshi Irie[1], Taiki Fukuda[1], Victor Tee Sin Loong[1], Daiki Maekawa[1], Yusuke Ito[1], Takamasa Akiyama[1], Taiitiro Mashiko[1], Kohei Izumi[1], Yohei Yamano[1], Masayuki Ando[1], Yu Kato[1], Ryu Yamamoto[1], Takanari Kida[1], Shinya Takemura[1], Yuhdai Suzuki[1], Nung Duk Yun[1], Shigechika Miki[2], Yoshitaka Nishizaki[3], Kenji Kanemasu[4], Hajime Sakamoto[5]

[1]Chiba Institute of Technology, 2-17-1 Tsudanuma, Narashino, Chiba, JAPAN
yasuo.hayashibara@it-chiba.ac.jp
[2]Miki Seisakusyo Co, Ltd., 1-7-28 Ohno, Nishiyodogawa, Osaka, JAPAN
[3]Nishizaki Co, Ltd., 1-7-27 Ohno, Nishiyodogawa, Osaka, JAPAN
[4]Yosinori Industry,Ltd., 1-2-23 Owada, Nishiyodogawa, Osaka, JAPAN
[5]Hajime Research Institute, Ltd., 1-7-28 Ohno, Nishiyodogawa, Osaka, JAPAN

Abstract. In this paper, we describe our robot system for the RoboCup soccer kid size humanoid league. The system we developed has high mobility, strong kicks, well-designed control system, position estimation by a monocular camera and user-friendly interface. The robot can walk speedy and robustly. It also has a feedback system with gyro and acceleration sensors to prevent falls. It detects the positions of landmarks by color-based image processing. A particle filter is employed to localize the robot in the soccer field fusing motion model and landmark observation. All system was redesigned two years ago for improving the ease of maintenance and the flexibility. Now we are developing a new walking pattern generator using the predictive control. We are also developing a new planning method for decision making.

Keywords: humanoid, ease of maintenance, education tool

1 Introduction

In this paper, we describe our system for the RoboCup soccer kid size humanoid league. Our robot is well-designed and controlled robustly. Last year, we got the first prize of technical challenge and forth place of 3on3 soccer in RoboCup 2013 Eindhoven and the first prize of 3on3 soccer in RoboCup Japan Open 2013. Our team consists of specialists from various technological areas. We integrate our technologies to develop an intelligent humanoid robot. Hajime Research Institute developed the mechanism and control system of the robot. Chiba Institute of Technology developed computer system and overall intelligence such as image recognition and soccer algorithm. We would like to emphasize that the most of members are undergraduate students. Through this development, the professors try to make an educational and research platform robot system of intelligent humanoid. In this year, our development effort is mainly put in new walking pattern generator and decision making framework of the soccer strategy.

2 Overview of the System

A photograph of our robot is shown in Fig.1. The specification of the robot is indicated in Table 1. The overview of the hardware and software system is shown in Fig. 2 and 3. Fig. 4 shows the control circuits which we developed. Our robot system consists of a USB camera, a computer board, an Inertial Measurement Unit (IMU), 17 servo motors, a battery and some user interfaces such as switches. All tasks including perception, planning and control are executed on the computer board. Two processes are executed on a single computer: a main process for perception and planning and a control process. Images are captured by the USB camera, and processed on the computer board to detect the position of the ball, other robots and landmarks. The robot estimates self-position using the obtained information and selects a next behavior. The behaviors which we can choose are not only just simple moving, but also complex task like following ball. The robot operates body control tasks in a dedicated process. Several pre-defined behaviors such as walk and kick are stored as data files and a command to choose a behavior is sent from the main process to the body control process. The control process decodes and executes the command. It sometimes returns the status data to the main process. If the command is a kind of moving the body or checking a status, the main process sends a command to the body control process. Each servo motor has its own micro-controller to control a motor and receive/send commands. Because all servo motors are daisy-chained, the commands are sent to all motors. A command includes ID number so that the servo motor can identify to which the command is sent. The servo motor decodes and executes the command. The displacement angle is controlled in local motor unit. Soccer strategy programs are written in Python and executed in the main process. Other part of the main process and the entire control process are written in C and C++.

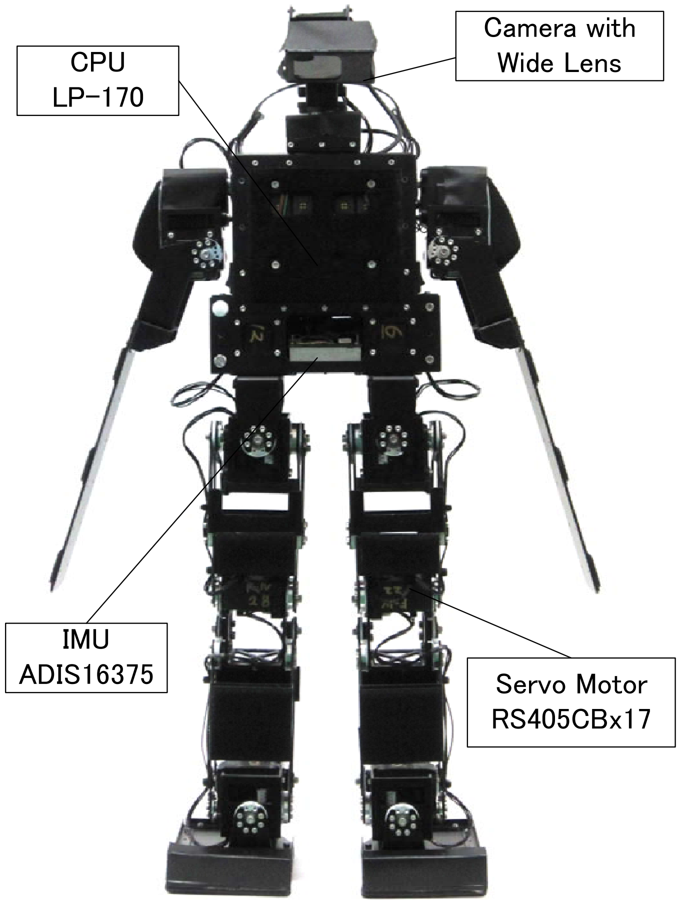


Fig.1. Structure of the Robot

Table 1. Specification of the Robot

Weight	3.5 kg (Including Batteries)
Height	600 mm
Velocity (Forward)	0.4 m/s (maximum)
Walking Directions	All direction and rotation (Select the angle, stride, period and so on)
CPU Board	COMMEL LP-170C (Intel Atom D525 1.8GHz)
OS	Linux (Ubuntu12.04LTS)
Interface	Ethernet x 1, USB x 4, CF x 1, RS232C x 2, Sound In/Out , Digital I/O, etc
Servo Motor	Futaba RS405CB x 17
Battery	3S (11.1V, 5000mAh)

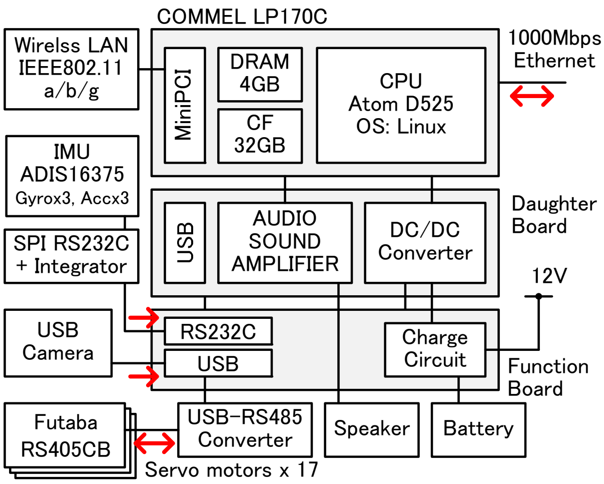


Fig.2. Overview of the Hardware System

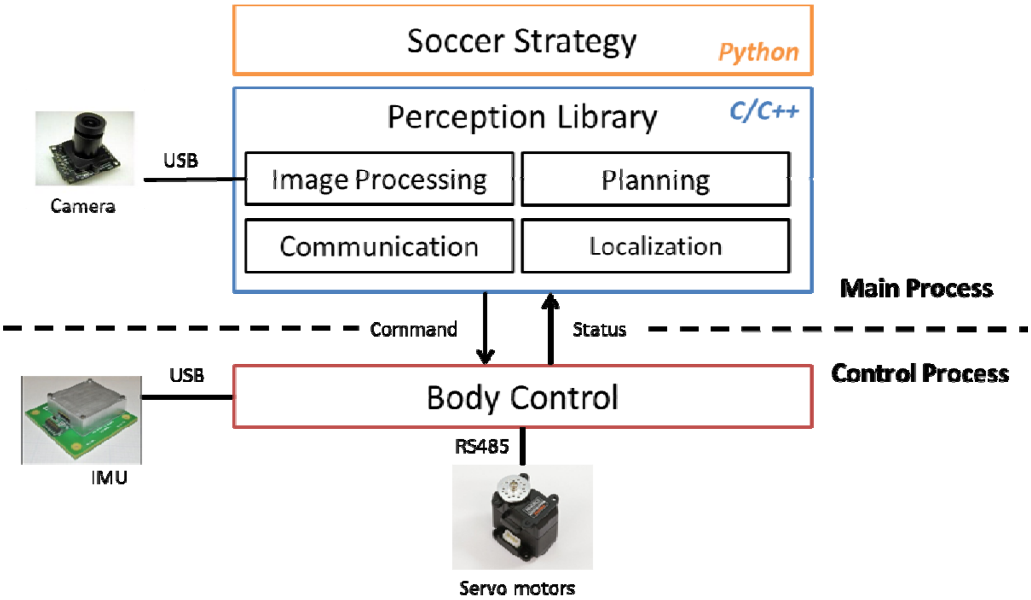
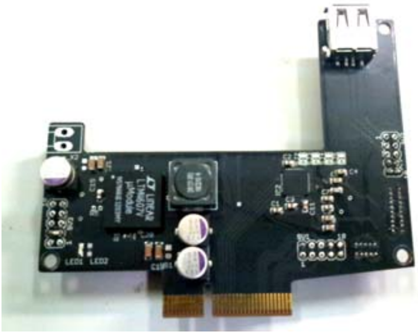
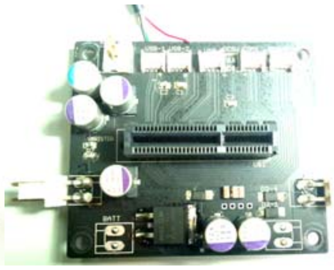


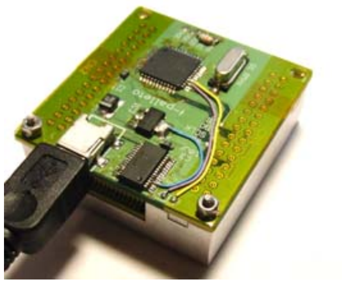
Fig.3. Architecture of the Software System



(a) Daughter Board



(b) Function Board



(c) Interface Circuit for IMU Sensor

Fig.4. Developed Control Circuits

3 Mobility

One of the significant features of our robot is the mobility. Through trial and error process, our robot can walk speedily and robustly. Its maximum speed is approximately 0.4m/s.

The body control process operates functions such as walking, kicking, returning the status data and so on. The body control process decodes and executes commands from the main process. If the command is related to servo motor control such as walk, motion generation and read status, the controller sends a command to servo motors via RS485. The control process also receives data from IMU via USB, which are used to modify the walking motion to prevent falls. The robot does not usually fall alone, however, in a soccer game it sometimes falls when pushed by other robots. Even if the robot falls, it detects its posture and stands up smoothly.

We improved the leg structure by using a parallel mechanism as shown in the Fig. 5. The parallel mechanism generates vertical movement mechanically. Therefore, walking doesn't become unstable easily because it can lower the foot in parallel even if the motor has not synchronized completely while walking. In addition, servo motors with a big torque are chosen to overcome the increased weight of the battery.

Heat from the motors is suppressed by these factors, and the robot can walk stably even after long time operations.

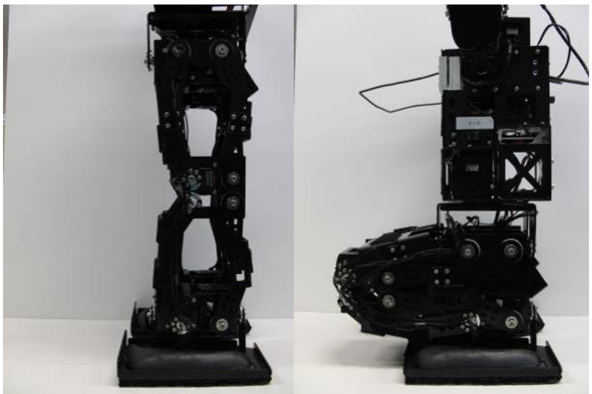
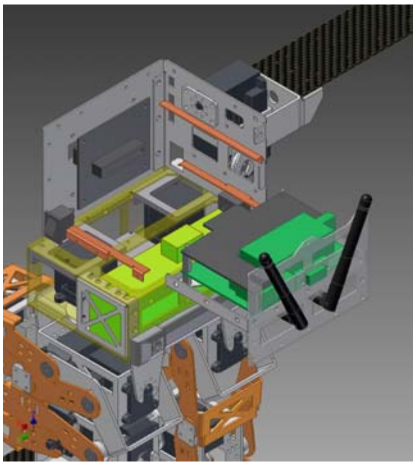


Fig.5. Parallel Mechanism of Foot

4 Computer System

One of significant feature of the robot is the high computational capability and the ease of maintenance. The computer in our robot is capable of processing VGA (640x480) images 20 frames per a second. The computer board has a laptop-class CPU (Atom D525) and Linux operating system is installed in it. It processes the image data, estimates the positions, determines the behavior and controls the whole body. Linux has advantages in ease of installation and operation compared to other operating systems we have previously used (Windows, NetBSD). Furthermore, for improving the ease of maintenance, we designed a slot-in mechanism of the main control circuit as shown in the Fig. 6. We could eliminate a huge number of cables. Moreover, it contains a charger circuit. Using an A/C adapter, we can charge batteries without external chargers.



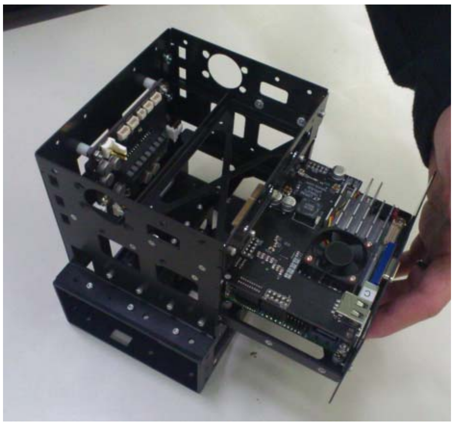


Fig.6 Slot-in System

5 Image Processing and Position Estimation

As mentioned above, the computer processes the image data of 20 frames per a second. The resolution of the images can be selected from 640x480 and 320x240. By simple image processing, it can detect the region of the same color. Object positions are calculated from the object position in an image and the pose of the camera under the assumption that all objects are on the floor. The pose of the camera is calculated by inverse kinematics. The result is send and displayed on a PC. The example of the calculation is shown in the Fig. 7. Before this image processing, we need to build a color look-up table. We made an interface to build the table smoothly. The operator can choose colors in an image displayed on GUI interface and verify the result immediately.

The robot position and orientation are estimated using a particle filter that fuses motion estimations and observations. An example of localization is shown in the Fig. 8. The hypotheses of robot position are represented by particles and they are updated as robot moves. When landmarks are observed, the particles are weighted and resampled.

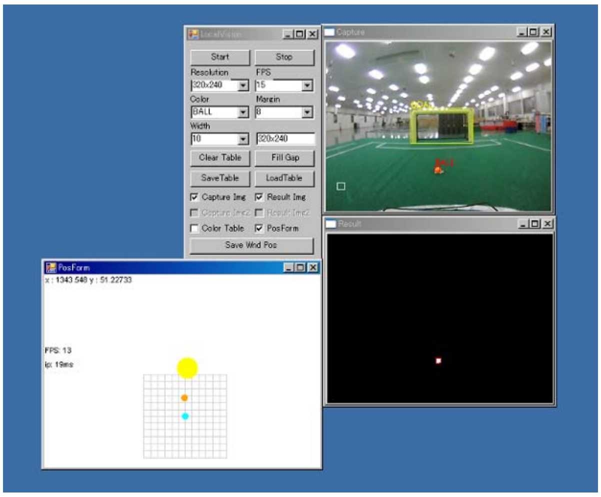


Fig.7 Graphical User Interface

Fig.8 Estimating Process Using Particle Filter

6 Soccer Strategy Development Environment

We developed a user-friendly interface for soccer strategy development environment. The programmer can interactively check many kinds of things in this interface. The functionalities provided by the interface are as follows.

[User operation]
1) send commands to the control process
2) build a color look-up table
3) execute strategy programs by its name

[Status monitoring]
1) image data (both raw and processed image)
2) detected objects and their position

3) estimated robot position and particles
4) debug messages
5) battery voltage and temperatures of servo motors

Since the interface displays most of the significant status of the robot, the programmer can check the algorism and find problems easily.

We developed a simulator using V-REP (Fig.9). V-REP is an open source robot simulator made by COPPELIA ROBOTICS. Almost all behaviors of robot such as motions and soccer strategies can be verified in this simulator. We can apply the verified code to the real robot without modification.

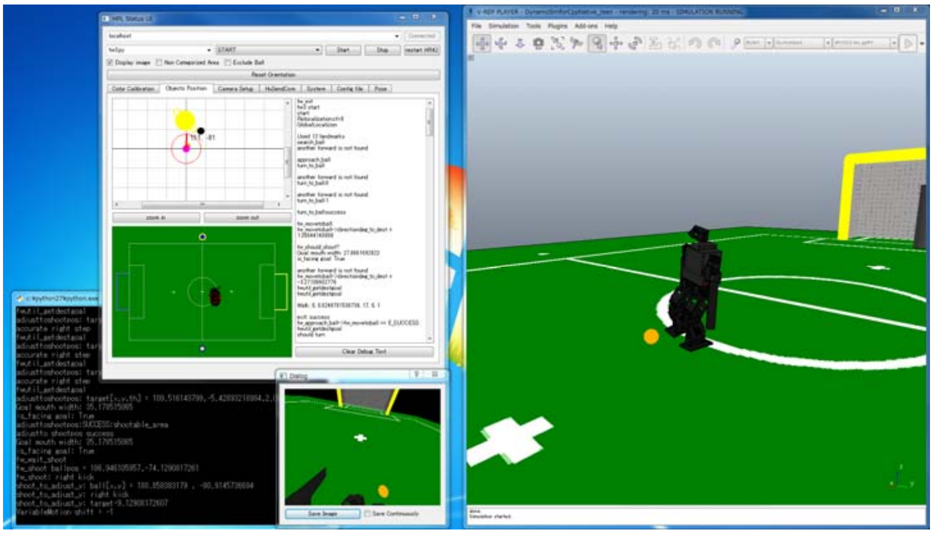


Fig.9 Simulator Software

7 Conclusion

In this paper we described our system. Our system has high mobility, strong kicks, well-designed control system, position estimation by one camera, user-friendly interface and simulator.